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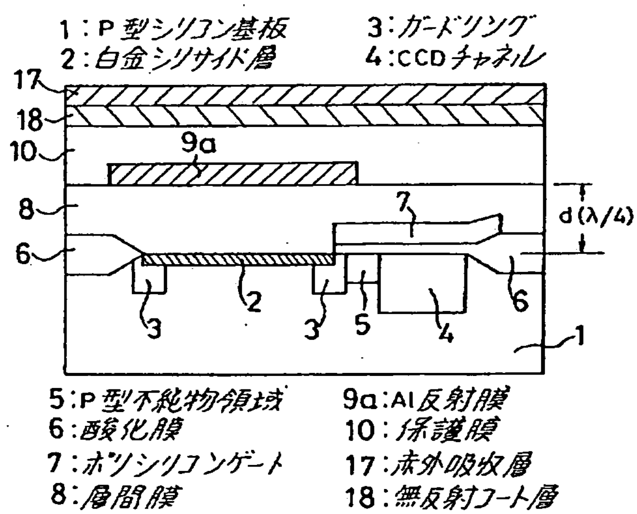
(54)【発明の名称】　赤外線固体撮像素子

(57)【要約】
【目的】　裏面入射型の赤外線固体撮像素子において、素子表面側から入射する散乱光などが画像に及ぼす影響を解消するとともに、素子の空間分解能を向上させる。
【構成】　裏面入射型の赤外線固体撮像素子において、赤外線検出器上方を覆うＡｌ反射層９ａよりも上方に、少なくとも不感領域を覆うようにして赤外線吸収層１７を設ける。



【特許請求の範囲】

【請求項1】 赤外線を透過させる半導体基板と、該半導体基板の表面の受光領域に設けられた赤外線検出器と、上記受光領域以外の不感領域に設けられ、前記検出器により検出された光電荷を読み出す電荷読み出し器と、上記受光領域上方を覆う反射膜とを備え、上記半導体基板裏面側より入射する赤外線を電気信号に変換する赤外線固体撮像素子において、

上記反射膜上側に位置し、上記不感領域を覆う領域に赤外吸収層を備えたことを特徴とする赤外線固体撮像素子。

【請求項2】 赤外線を透過させる半導体基板と、該半導体基板の表面の受光領域に設けられた赤外線検出器と、上記受光領域以外の不感領域に設けられ、前記検出器により検出された光電荷を読み出す電荷読み出し器と、上記受光領域上方を覆う反射膜とを備え、上記半導体基板裏面側より入射する赤外線を電気信号に変換する赤外線固体撮像素子において、

上記反射膜よりも上方で、かつ上記赤外線検出器から、上記入射する赤外線の約1／2波長あるいはその倍数の距離隔てた所定位置に、第2の反射膜を備えたことを特徴とする赤外線固体撮像素子。

【発明の詳細な説明】

【0001】

【産業上の利用分野】この発明は赤外線固体撮像素子に関し、特に基板裏面側から入射する赤外線を電気信号に変換する裏面入射型の構造を有するものに関するものである。

【0002】

【従来の技術】近年のシリコンＬＳＩ技術の進歩にともない、半導体基板上に多数の赤外線検出器を１次元または２次元アレイ状に配置した光電変換回路と、信号電荷読み出し用の電荷転送回路とを組み合わせた赤外線固体撮像素子が開発されている。中でも、赤外線検出器としてＰｔＳｉ／ｐ－Ｓｉショットキバリアダイオードを用い、電荷転送回路としてＣＣＤ(Charge Coupled Device：電荷結合素子）などを用いた３～５μm帯用赤外線固体撮像素子は、赤外レンズ，駆動回路，クーラーなどと組合せて赤外線カメラとして既に実用化されている。

【0003】図３は、基板の裏面側より入射する赤外線を電気信号に変換する（以下裏面入射型ともいう）従来の赤外線固体撮像素子の断面図である。図３において、１は比抵抗１０Ωｃｍ程度のＰ型シリコン基板、２は白金シリサイド（ＰｔＳｉ）層であり、これらにより形成されるショットキーバリアダイオードが赤外線検出器を構成している。また、３は赤外線検出器周辺部でのリーク電流を低減するために形成されたＮ型不純物領域からなるガードリング、４はＮ型不純物領域からなるＣＣＤ埋め込みチャネル、５は赤外線検出器からＣＣＤへの電荷転送を制御するトランスファーゲートのＰ型不純物領域、６はSiO_2などの酸化膜、７はポリシリコンゲート電極、８はSiO_2などの層間絶縁膜、９ａは上記層間絶縁膜８上の上記赤外線検出器を覆う領域に設けられたＡｌ反射膜、１０はSiO_2などの保護膜である。なおｄは光検出器の白金シリサイド（ＰｔＳｉ）層２からＡｌ反射膜９ａ間の距離を示す。

【０００４】次に動作について説明する。基板１裏面すなわち同図下方より検出器領域へ入射した赤外線は、シリコン基板１中を通過してＰｔＳｉ層２に達し、赤外線の一部はここで光電変換されて信号電荷を発生する。またこの時光電変換に寄与しなかった赤外線は、ＰｔＳｉ層２および層間絶縁膜８を通過し、検出器上部に形成されたＡｌ反射膜９ａによって反射されて再度ＰｔＳｉ層２に達し、ここでまた信号電荷を発生する。

【０００５】ところで上記過程において、Ａｌ反射膜９ａによって反射された反射赤外線が検出器に再入射した場合の光電変換効率は、赤外線検出器とＡｌ反射膜９ａとの距離ｄに依存する。図４を用いて詳述すると、図に示すように、光学的な共鳴現象のため反射赤外線の光電変換効率は、$d=\lambda/4$，$3\lambda/4$付近で極大（$\lambda/4$付近で最大）となり、$d=\lambda/2$付近で極小となることがわかる（ここでλは検出する赤外線の中心波長である）。そこで、反射赤外線の光電変換効率を高めるべく、図３に示した赤外線固体撮像素子では、検出波長が３～５μmであるから、ｄ＝０．７～１μm（$\lambda/4$）程度に設定されている。

【０００６】そして以上のようにして光検出器にて発生した信号電荷は、ＰｔＳｉ層２およびガードリング３中に蓄積され、ポリシリコンゲート７に正電圧が印加されてトランスファゲートがＯＮすることにより、Ｐ型不純物領域５を通してＣＣＤチャネル４へと流れ込む。その後、信号電荷は、ＣＣＤ動作によってＣＣＤチャネル４内を転送され、図示しない出力アンプから外部へと取り出される。なお、基板裏面側から光検出器が形成された領域以外の領域（不感領域）に入射した赤外線は、表面側へと素子を通過する。

【０００７】ところで、赤外線検出器として上述したようなＰｔＳｉ／ｐ－Ｓｉショットキーバリアダイオードなどを用いた場合には、赤外線検出器で発生する暗電流を抑えるために素子を７７Ｋ程度の低温に冷却する必要がある。このため、素子は冷却用クーラーに装着される。図５は、裏面入射型の赤外線固体撮像素子をクーラーに装着する場合の実装例を示す構成図である。

【０００８】図５において、１１は赤外線固体撮像素子、１２はパッケージ、１３は素子冷却用クーラーのヘッド部、１４は素子１１を保護するためのシリコンなどからなるスペーサー、１５は低温用接着剤、１６は赤外線入射窓である。

【０００９】次に各構成要素の役割について簡単に説明する。赤外線固体撮像素子１１は、低温用接着剤１５を

用いてパッケージ１２に装着され、このパッケージ１２には赤外線入射窓１６が開けられており、ここから入射した赤外線が赤外線固体撮像素子１１の基板裏面に当たるようになっている。また赤外線固体撮像素子１１とクーラーヘッド１３との間には、スペーサー１４が設けられており、素子１１とクーラーヘッド１３との熱膨張係数の違いによって冷却時に生じる熱応力が、直接素子１１に加わらないような構造となっている。なお素子１１，スペーサー１４，クーラーヘッド１３の各接着にも低温用接着剤１５が用いられる。

【００１０】しかるに図３に示した従来の赤外線固体撮像素子は、光検出器が形成された以外の領域（不感領域）に入射した赤外線が素子を透過する構造となっているため、図５のように撮像素子をクーラーヘッドに装着すると、不感領域に入射し撮像素子を透過した赤外線が、素子１１／接着剤界面，接着剤／スペーサー界面，スペーサーのエッジ部分などで散乱され、この時散乱の程度は素子表面の状態等に大きく左右され、場合によっては散乱光の光検出基板への再入射により、接着剤の塗布ムラなどが検出器出力に現われ、画像ムラを生じるという問題があった。

【００１１】そこで、図６に示すように、不感領域に入射した赤外線が素子を通過しない構造の赤外線固体撮像素子が案出されている。すなわち、検出器領域だけでなく不感領域も含む画素領域全体をＡｌ反射膜９ｂで覆うことにより、素子裏面側から不感領域に入射した光も全て反射させて散乱光を生じないようにしている。このとき、Ａｌ反射膜９ｂが完全に平坦でない場合や、赤外線が斜めに入射する場合には、再入射する赤外線が増加して見掛け上の光電変換効率は向上するが、不感領域に入射した赤外線が再入射するものであるため、撮像素子としての空間的な分解能は低下することとなる。

【００１２】

【発明が解決しようとする課題】従来の赤外線固体撮像素子は以上のように構成されており、不感領域に入射した赤外光がクーラーヘッドの接着剤の塗布ムラやスペーサー周辺部にて散乱されて画像ムラを生じたり、また不感領域に入射した赤外光が光検出器に再入射して撮像素子の空間分解能を低下させるという問題点があった。

【００１３】この発明は上記のような問題点を解決するためになされたもので、素子表面側から入射する散乱光をなくし画像ムラを解消するとともに、不感領域に入射した赤外光の再入射により素子の空間的分解能が低下することのない赤外線固体撮像素子を得ることを目的とする。

【００１４】

【課題を解決するための手段】この発明に係る赤外線固体撮像素子は、反射膜上側に位置し、不感領域を覆う領域に赤外線吸収層を設けたものである。

【００１５】あるいは、上記反射膜上側、かつ赤外線検出器から、入射する赤外線の１／２波長あるいはその倍数程度の距離隔てた所定位置に、第２の反射膜を設けたものである。

【００１６】

【作用】この発明においては、反射膜よりも上方で、不感領域を覆う領域に赤外線吸収層が設けられているため、不感領域を通過した赤外光はここで吸収され光検出器に再入射することがない。

【００１７】あるいは、反射膜上側、かつ赤外線検出器から、入射する赤外線の１／２波長あるいはその倍数程度の距離隔てた所定位置に、第２の反射膜が設けられているため、赤外線が不感領域を通過して第２の反射膜により反射され光検出器に入射しても光学共鳴により光検出器での光電変換は殆ど起こらない。

【００１８】

【実施例】以下、この発明の一実施例による裏面入射型赤外線固体撮像素子を図について説明する。図１において図３と同一符号は同一または相当部分を示し、１７は例えば高濃度にリンドープされたポリシリコンなどからなる赤外吸収層、１８は保護膜１０と赤外吸収層１７との界面での赤外線反射を防ぐために設けられたSiO_2などからなる無反射コート層である。

【００１９】次に動作について説明する。まず素子の基板裏面側から検出器へと赤外線が入射した場合の動作は、従来の赤外線固体撮像素子の場合と同様であるため、ここではその説明は省略する。一方、基板裏面側から不感領域に入射した赤外線は、素子を通過して赤外吸収層１７に達しここで吸収されるため、クーラーヘッドの接着剤の塗布ムラやスペーサー周辺部にて散乱されて検出器へ再入射することがなく、従って画像ムラ等の問題は起こらない。このとき、無反射コート層１８の存在によって、赤外吸収層１７と無反射コート層１８との界面、および無反射コート層１８と保護膜１０との界面での赤外線反射は生じない。さらに、素子表面側から入射する赤外線に対しては、赤外吸収層１７が遮蔽層として作用することとなり、仮に何らかの理由により素子表面から赤外光が入射（迷光という）してもこれが光電変換されることはない。

【００２０】なお上記実施例では赤外吸収層１７の下方に無反射コート層１８を形成したが、赤外吸収層１７と保護膜１０との材質の組合せ方によって、これら２部材間の屈折率の比が所定範囲内にある場合、これら界面での赤外線反射が殆ど起こらない場合があり、この場合は無反射コート層１８を形成する必要はなく、保護膜１０上に赤外吸収層１７を直接形成してもよい。

【００２１】このように本実施例によれば、保護膜１０上に無反射コート１８，赤外吸収層１７を順次積層して設けたから、光検出器が形成されていない不感領域を通過した赤外線は赤外吸収層１７にて吸収されるようになり、素子をクーラーヘッドに取付けても赤外線が散乱し

て光検出器に再入射することがなく、赤外線の散乱による画像ムラを防止することができる。

【0022】次に本発明の第2の実施例を図2を用いて説明する。この実施例では光検出器上方を覆うように（第1の）Ａｌ反射膜９ａを設けるとともに、保護膜１０上に画素全域を覆う第２のＡｌ反射膜１９を形成し、不感領域を通過した赤外光を第２のＡｌ反射膜１９にて反射させ、光学共鳴を利用して光電変換効率を低下させるようにしたものである。

【0023】詳述すると図において、１９は保護膜１０上に、光検出器からの距離Ｄがλ／２付近になるように形成された第２のＡｌ反射膜であり、２０はこの第２のＡｌ反射膜１９上に形成された保護層である。なお、このときも第１反射膜９ａは上記で説明したように、光電変換効率が最大となる位置、すなわち赤外線検出器からλ／４付近の位置に形成される。

【0024】次に動作について説明する。上記実施例と同様に素子の基板裏面側から検出器へと赤外線が入射した場合の動作は、従来の赤外線固体撮像素子の場合と同様であるため、ここではその説明は省略する。一方、基板裏面側から不感領域に入射した赤外線は、素子を通過して第２のＡｌ反射膜１９で反射され、その一部が検出器へ再入射する。このとき、検出器と第２のＡｌ反射膜１９との距離Ｄがλ／２であるため、この時の光電変換効率は図４で説明したように光学共鳴のため極小であるため、反射光が検出器に再入射しても光電変換はほとんど起こらず、撮像素子としての空間的な分解能は向上する。さらに、素子表面側から入射する赤外線に対しては、第２の反射膜１９が遮蔽層として作用するため迷光対策となる。

【0025】また、第１の反射膜９ｂは検出器領域のみを覆うように形成されており、不感領域を通過した赤外光の殆どは第２のＡｌ反射膜１９にて反射されるため、光電変換される赤外光は、受光部のみを通過したものが大部分となるため、素子の空間的分解能は従来に比べ向上する。また第２のＡｌ反射膜１９の位置は光検出器からλ／２の整数倍の距離に配置してもよいが、装置のコンパクト化の点からλ／２の距離に設けるのが望ましい。

【0026】なお上記各実施例においては、赤外吸収層１７もしくは第２の反射膜１９が画素領域の全域を覆うように形成されたものを示したが、これは画素領域のうち少なくとも光検出器が形成されていない不感領域の上部にこれらの層１７，１９を形成すればよいものであり、この場合も同様の効果を奏する。

【0027】また、上記赤外線固体撮像素子が対象とする赤外線波長は、３～５μｍ帯にのみ制限されるものではなく、例えば１０μｍ帯でもよい。この場合、ＩｒＳｉまたはＳｉＧｅ／ＰｔＳｉなどを赤外線検出器に用い、赤外吸収層のリン濃度を変更するなどの手段を講ずればよい。

【0028】

【発明の効果】以上のように、この発明に係る赤外線固体撮像素子によれば、反射膜上側に位置し、不感領域を覆う領域に赤外線吸収層を設けたので、基板裏面側から不感領域へと入射した赤外線は赤外吸収層により吸収されて光検出器に再入射することがなく、画像ムラをなくすことができるという効果がある。

【0029】あるいは、反射膜上側、かつ赤外線検出器から、入射する赤外線の１／２波長あるいはその倍数程度の距離隔てた所定位置に、第２の反射膜が設けたので、基板裏面側から不感領域へと入射した赤外線が第２の反射膜により反射されて光検出器に入射しても、光学共鳴により光検出器での光電変換は殆ど起こらず、撮像素子としての空間分解能を向上させることができるという効果がある。

【図面の簡単な説明】

【図１】この発明の一実施例による赤外線固体撮像素子を示す断面図。

【図２】この発明の第２の実施例による赤外線固体撮像素子を示す断面図。

【図３】従来の裏面入射型赤外線固体撮像素子を示す断面図。

【図４】上記裏面入射型赤外線固体撮像素子において、検出器－反射膜間距離（ｄ）と反射赤外線の光電変換効率との関係を示す図。

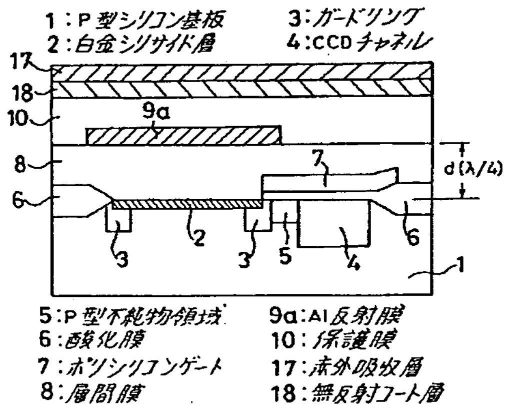
【図５】裏面入射型赤外線固体撮像素子をクーラーに装着する場合の実装方法の一例を示す構成図。

【図６】従来の裏面入射型赤外線固体撮像素子の他の例を示す断面図。

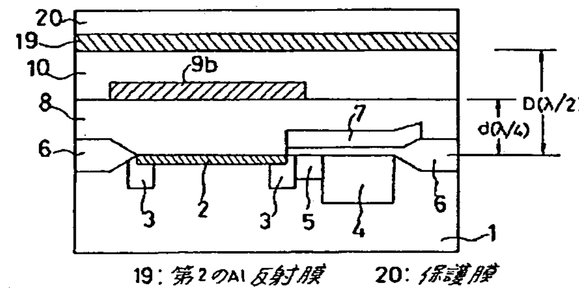
【符号の説明】

１　Ｐ型シリコン基板
２　白金シリサイド層
３　ガードリング
４　ＣＣＤチャネル
５　Ｐ型不純物領域
６　酸化膜
７　ポリシリコンゲート
８　層間絶縁膜
９　Ａｌ反射膜（第１の反射膜）
１０　保護膜
１７　赤外吸収層
１８　無反射コート層
１９　Ａｌ反射膜（第２の反射膜）
２０　保護膜

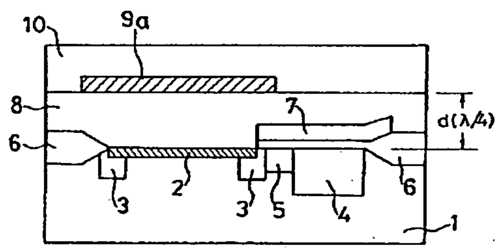
【図1】



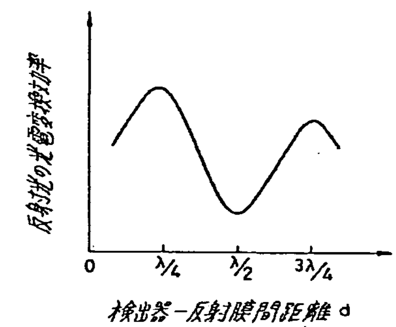
【図2】



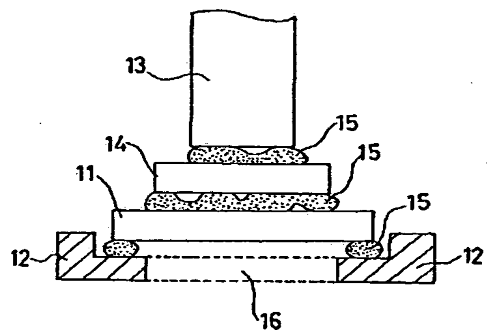
【図3】



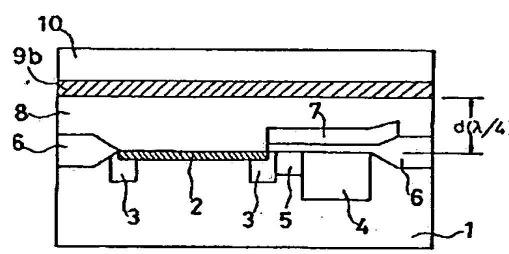
【図4】



【図5】



【図6】



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(54)[Title of the Invention]

INFRARED SOLID-STATE IMAGING DEVICE

(57)[Abstract]

[Object] To eliminate an influence of a scattered light or the like incident from a device front surface on a rear surface incident infrared solid-state imaging device and to improve a spatial resolution of the imaging device.

[Constitution] In a rear surface incident infrared solid-state imaging device, an infrared absorption layer 17 is provided above an Al reflecting layer 9a covering an upper portion of an infrared detector so that the layer 17 covers at least an insensitive region.

[What is claimed is]

[Claim 1] An infrared solid-state imaging device comprising:

a semiconductor substrate that transmits an infrared ray;

an infrared detector provided in a light receiving region on a front surface of the semiconductor substrate;

a charge reader provided in an insensitive region other than said light receiving region, and reading an optical charge detected by said detector; and

a reflecting film covering an upper portion of said light receiving region, wherein

the infrared solid-state imaging device converts the infrared ray incident from a rear surface of said semiconductor substrate to an electric signal, characterized by comprising:

an infrared absorption layer located above said reflecting film and provided in a region covering said insensitive region.

[Claim 2] An infrared solid-state imaging device comprising:

a semiconductor substrate that transmits an infrared ray;

an infrared detector provided in a light receiving

region on a front surface of the semiconductor substrate;

a charge reader provided in an insensitive region other than said light receiving region, and reading an optical charge detected by said detector; and

a reflecting film covering an upper portion of said light receiving region, wherein

the infrared solid-state imaging device converts the infrared ray incident from a rear surface of said semiconductor substrate to an electric signal, characterized by comprising:

a second reflecting film provided at a predetermined position above said reflecting film and away from said infrared detector by a distance of about a half of a wavelength of said incident infrared ray or about an integer multiple of the half of the wavelength of said incident infrared ray.

[Detailed Description of the Invention]

[0001]

[Industrial Field of the Invention]

This invention relates to an infrared solid-state imaging device and particularly relates to a rear surface incident infrared solid-state imaging device which converts an infrared ray incident from a rear surface of a substrate to an electric signal.

[0002]

[Prior Art]

Following the recent development of silicon LSI technique, infrared solid-state imaging devices each of which consists of a photoelectric conversion circuit having many infrared detectors in a one-dimensional array or a two-dimensional array on a semiconductor substrate and a charge transfer circuit for signal charge reading are developed. Among the infrared solid-state imaging devices, an infrared solid-state imaging device for a band of three to five micrometers that employs a PtSi/p-Si Schottky barrier diode as each infrared detector and that employs a CCD (Charge Coupled Device) or the like as the charge transfer circuit is already put to practical use in combination with an infrared lens, a driving circuit, a cooler or the like.

[0003]

Fig. 3 is a cross-sectional view of a conventional infrared solid-state imaging device that converts an infrared ray incident from a rear surface of a substrate to an electric signal (which device will be referred to as "rear surface incident infrared solid-state imaging device" hereinafter). In Fig. 3, reference symbol 1 denotes a P-type silicon substrate having a specific resistance of about 10 Ωcm and 2 denotes a platinum silicide (PtSi) layer. A Schottky barrier diode, which

consists of the P-type silicon substrate 1 and the PtSi layer 2, constitutes an infrared detector. Reference symbol 3 denotes a guard ring formed to reduce a leak current in infrared detector peripheral portions and consisting of an N-type impurity region, 4 a CCD-buried channel consisting of an N-type impurity region, 5 a P-type impurity region of a transfer gate that controls charge transfer from the infrared detector to the CCD, 6 an oxide film made of SiO_2 or the like, 7 a polysilicon gate electrode, 8 an interlayer insulating film made of SiO_2 or the like, 9a an Al reflecting film provided in a region covering the infrared detector on the interlayer insulating film 8, and 10 a protection film made of SiO_2 or the like. In Fig. 3, symbol d denotes a distance from the PtSi layer 2 of the photo-detector to the Al reflecting film 9a.

[0004]

Next, operations of the conventional imaging device will be described. The infrared ray incident on a detector region from the rear surface of the substrate 1, i.e., from the lower part of Fig. 3 is caused to pass through the silicon substrate 1 and reaches the PtSi layer 2. Part of the infrared ray is subjected to photoelectric conversion in the PtSi layer 2 and a signal charge is generated. At this moment, the remaining infrared ray which has not contributed to the

photoelectric conversion is caused to pass through the PtSi layer 2 and the interlayer insulating film 8, reflected by the Al reflecting film 9a formed above the detector, and reaches the PtSi layer 2 again to thereby generate a signal charge again in the layer 2.

[0005]

In this process, the photoelectric conversion efficiency of the infrared ray reflected by the Al reflecting film 9a when the infrared ray is incident on the detector again depends on the distance d between the infrared detector and the Al reflecting film 9a. The distance dependency of the photoelectric conversion efficiency will be described in detail with reference to Fig. 4. As shown in Fig. 4, the photoelectric conversion efficiency of the reflected infrared ray has relative maximums when the distance d is close to $\lambda/4$ and $3\lambda/4$ (a maximum at the distance close to $\lambda/4$) and relative minimums when the distance d is close to $\lambda/2$ because of an optical resonance phenomenon (where λ is a center wavelength of the detected infrared ray). To enhance the photoelectric conversion efficiency of the reflected infrared ray, the distance d is set between about 0.7 and about 1 micrometer ($\lambda/4$) since a detection wavelength of the infrared solid-state imaging device shown in Fig. 3 is three to five micrometers.

[0006]

The signal charges generated by the photo-detector as stated above are accumulated in the PtSi layer 2 and the guard ring 3. When a positive voltage is applied to the polysilicon gate 7 and the transfer gate is thereby turned on, the accumulated signal charges flow into the CCD channel 4 through the P-type impurity region 5. Thereafter, the signal charges are transferred within the CCD channel 4 by a CCD operation, and taken out from an output amplifier, not shown. It is noted that the infrared ray, which is incident from the substrate rear surface on a region (an insensitive region) other than the region in which the photo-detector is formed, is caused to pass through the device toward the front surface of the substrate.

[0007]

Meanwhile, if the above-stated PtSi/p-Si Schottky barrier diode or the like is employed as the infrared detector, the device needs to be cooled to a temperature as low as about 77K so as to suppress a dark current generated in the infrared detector. To do so, the device is installed in a cooler for cooling the device. Fig. 5 is a block diagram illustrating an example in which the rear surface incident infrared solid-state imaging device is installed in the cooler.

[0008]

In Fig. 5, reference symbol 11 denotes an infrared

solid-state imaging device, 12 a package, 13 a head of the device cooling cooler, 14 a spacer which protects the device 11 and which is made of silicon or the like, 15 an adhesive for low temperature, and 16 an infrared entrance window.

[0009]

Functions of the respective constituent elements will next be described briefly. The infrared solid-state imaging device 11 is attached to the package 12 using the low temperature adhesive 15. The infrared entrance window 16 is formed in this package 12 so that the infrared ray incident from the window 16 strikes against the rear surface of the substrate of the infrared solid-state imaging device 11. In addition, the spacer 14 is provided between the imaging device 11 and the cooler head 13 so as to prevent a thermal stress generated during the cooling of the imaging device 11 because of a difference in coefficient of thermal expansion between the device 11 and the cooler head 13 from being directly applied to the device 11. The low temperature adhesive 15 is also employed to attach the device 11 to the spacer 14 and attach the spacer 14 to the cooler head 13.

[0010]

However, the conventional infrared solid-state imaging device has the following problems. The device shown in Fig. 3 has a structure in which the infrared

ray incident on the region (insensitive region) other than the region in which the photo-detector is formed is caused to pass through the device. Due to this, if the imaging device is attached to the cooler head as shown in Fig. 5, the infrared ray that has been incident on the insensitive region and passed through the imaging device is scattered on a boundary between the device 11 and the adhesive, a boundary between the adhesive and the spacer, edges of the spacer and the like. Scattering degree largely relies on a state of the surface of the device and the like. In some cases, because the scattered light is incident again on the substrate of the detector, application irregularities of the adhesive and the like occur to an output of the detector. As a result, image irregularities disadvantageously occur.

[0011]

To prevent the problems, therefore, there is proposed an infrared solid-state imaging device having a structure in which the infrared ray incident on the insensitive region is not caused to pass through the device as shown in Fig. 6. That is, by providing an Al reflecting film 9b covering not only the detector region but also an entire pixel region including the insensitive region, the light incident on the insensitive region from the rear surface of the device is totally reflected by the reflecting film 9b and

occurrence of the scattered light is thereby prevented. In this case, if the Al reflecting film 9b is not completely flat or the infrared ray is incident aslant, the quantity of the infrared ray that reenters the device increases and the apparent photoelectric conversion efficiency of the reflected ray is enhanced. However, since the infrared ray that entered the insensitive region is incident on the device again, the spatial resolution of the imaging device is deteriorated.

[0012]

[Problems that the Invention is to Solve]

The conventional infrared solid-state imaging device, which is constituted as stated above, has the following problems. The infrared ray incident on the insensitive region causes application irregularities of the adhesive used for the cooler head. In addition, the infrared ray is scattered in the peripheral portions of the spacer to cause image irregularities. Further, the infrared ray incident on the insensitive region reenters the photo-detector, thereby disadvantageously deteriorating the spatial resolution of the imaging device.

[0013]

This invention has been made to solve these problems. It is an object of this invention to provide an infrared solid-state imaging device capable of

eliminating a scattered light incident from a front surface of the imaging device to thereby eliminate image irregularities, and capable of preventing the deterioration of the spatial resolution of the imaging device caused by the reentrance of the infrared ray which has been incident on an insensitive region.

[0014]

[Means for Solving the Problems]

An infrared solid-state imaging device according to this invention has an infrared absorption layer provided in a region located above a reflecting film and covering an insensitive region.

[0015]

Otherwise, the infrared solid-state imaging device has a second reflecting film provided at a predetermined position above the reflecting film and away from the infrared detector by a distance of about a half of a wavelength of an incident infrared ray or about an integer multiple of the half of the wavelength of the incident infrared ray.

[0016]

[Function]

According to this invention, since the infrared absorption layer is provided in the region above the reflecting film and covering the insensitive region, the infrared ray that has been caused to pass through the

insensitive region is absorbed by the infrared absorption layer and is not incident again on the photo-detector.

[0017]

Otherwise, the second reflecting film is provided at the predetermined position above the reflecting film and away from the infrared detector by a distance of about half the wavelength of the incident infrared ray or about an integer multiple of the half of the wavelength of the incident infrared ray. Therefore, even if the infrared ray is passed through the insensitive region, reflected by the second reflecting film, and incident on the photo-detector, photoelectric conversion derived from optical resonance hardly occurs to the photo-detector.

[0018]

[Embodiments]

A rear surface incident infrared solid-state imaging device in the first embodiment of this invention will be described hereinafter with reference to the drawings. In Fig. 1, the same reference symbols as those in Fig. 3 denote the same or corresponding constituent elements, respectively. Reference symbol 17 denotes an infrared absorption layer made of, for example, polysilicon heavily doped with phosphorus, and 18 denotes a non-reflection coat layer provided to prevent

infrared reflection on a boundary between the protection film 10 and the infrared absorption layer 17 and made of SiO_2 or the like.

[0019]

Operations of the imaging device in this embodiment will next be described. The operations of the imaging device if the infrared ray is incident on the detector from the rear surface of the substrate of the device are the same as those of the conventional infrared solid-state imaging device. Therefore, they will not be described herein. On the other hand, the infrared ray incident on the insensitive region from the rear surface of the substrate is caused to pass through the device, arrives at the infrared absorption layer 17, and is absorbed by the layer 17. Due to this, the application irregularities of the adhesive for the cooler head do not occur. In addition, since the infrared ray is not scattered on the peripheral portions of the spacer and is not incident on the detector again, problems such as image irregularities do not occur. At this time, because of the presence of the non-reflection coat layer 18, the reflection of the infrared ray does not occur on the boundary between the infrared absorption layer 17 and the non-reflection coat layer 18 and that between the non-reflection coat layer 18 and the protection film 10. Further, the infrared absorption layer 17 acts as a

shielding layer against the infrared ray incident from the front surface of the device. Even if the infrared ray is incident from the front surface of the device for some reason (which infrared ray is referred to as "stray light"), the infrared ray is not subjected to photoelectric conversion.

[0020]

In this embodiment, the non-reflection coat layer 18 is formed below the infrared absorption layer 17. However, if a ratio of a refractive index of the infrared absorption layer 17 to that of the protection layer 10 falls within a predetermined range, depending on a combination of a material for the infrared absorption layer 17 and that for the protection layer 10, the infrared reflection sometimes hardly occurs on the boundary between the two members. In this case, it is unnecessary to form the non-reflection coat layer 18 but the infrared absorption layer 17 may be directly formed on the protection film 10.

[0021]

As described above, in this embodiment, the non-reflection coat 18 and the infrared absorption layer 17 are sequentially built up on the protection film 10. Therefore, the infrared ray which has been caused to pass through the insensitive region in which the photo-detector is not formed is absorbed by the infrared

absorption layer 17. Accordingly, even if the imaging device is attached to the cooler head, the infrared ray is not scattered and not incident on the photo-detector again, thereby making it possible to prevent the image irregularities caused by the scattering of the infrared ray.

[0022]

The second embodiment of this invention will next be described with reference to Fig. 2. In the second embodiment, the (first) Al reflecting film 9a is provided to cover the upper portion of the photo-detector and a second Al reflecting film 19 which covers an entire pixel region is formed on the protection film 10, whereby the infrared ray which has been passed through the insensitive region is reflected by the second Al reflecting film 19 and the photoelectric conversion efficiency is deteriorated by utilizing the optical resonance.

[0023]

The second embodiment will be described in detail. In Fig. 2, reference symbol 19 denotes the second Al reflecting film formed on the protection film 10 so that a distance D from the photo-detector to the film 19 is close to $\lambda/2$, and reference symbol 20 denotes a protection layer formed on this second Al reflecting film 19. As described above, the first reflecting film

9a is formed at a position at which the photoelectric conversion efficiency reaches a maximum, i.e., at a position away from the infrared detector by about λ/4.

[0024]

Operations of the imaging device in the second embodiment will next be described. Similarly to the first embodiment, the operations of the device if the infrared ray is incident on the detector from the rear surface of the substrate of the device are the same as those of the conventional infrared solid-state imaging device. Therefore, they will not be described herein. On the other hand, the infrared ray incident on the insensitive region from the rear surface of the substrate is caused to pass through the device and reflected by the second Al reflecting film 19 while part of the infrared ray is incident on the detector again. At this moment, the distance D between the detector and the second Al reflecting film 19 is λ/2. At the distance D of λ/2, the photoelectric conversion efficiency has a relative minimum because of the optical resonance as described above with reference to Fig. 4. As a result, even if the reflected light is incident on the detector again, the photoelectric conversion hardly occurs and the spatial resolution of the imaging device is enhanced. Moreover, since the second Al reflecting film 19 acts as a shielding layer against the infrared ray incident from

the front surface of the device, the incidence of the stray light is prevented.

[0025]

Furthermore, the first reflecting film 9b is formed to cover only the detector region and most of the infrared ray which has been caused to pass through the insensitive region is reflected by the second Al reflecting layer 19. As a result, most of the infrared ray subjected to the photoelectric conversion is the infrared ray which has been caused to pass only through the light receiving section. The spatial resolution of the device is, therefore, enhanced from that of the conventional device. Besides, the second Al reflecting film 19 may be provided at a position away from the photo-detector by a distance of an integer multiple of λ/2. Preferably, the second Al reflecting film 19 is provided at a position away from the photo-detector by λ/2 with a view of making the device compact.

[0026]

In the first and second embodiments stated above, either the infrared absorption layer 17 or the second Al reflecting layer 19 is formed to cover the entire pixel region. However, it suffices that the layer 17 or 19 is formed on at least part of the pixel region, i.e., the insensitive region in which the photo-detector is not formed. In this case, the same advantages as those

stated above can be attained.

[0027]

Furthermore, the wavelengths of the target infrared ray of the infrared solid-state imaging devices are not limited to those in the band of three to five micrometers but may be those in, for example, a band of ten micrometers. In this case, IrSi, SiGe/PtSi or the like may be used as a material for the infrared detector, and the phosphorus concentration of the infrared absorption layer may be changed.

[0028]

[Advantage of the Invention]

As described so far, the infrared solid-state imaging device according to this invention has the infrared absorption layer provided in the region located above the reflecting film and covering the insensitive region. Therefore, the infrared ray incident on the insensitive region from the rear surface of the substrate is absorbed by the infrared absorption layer and is not incident again on the photo-detector. It is thereby advantageously possible to eliminate the image irregularities.

[0029]

Further, the second reflecting film is provided at the predetermined position above the reflecting film and away from the infrared detector by a distance of about

half the wavelength of the incident infrared ray or approximately a multiple of the wavelength of the incident infrared ray. Therefore, even if the infrared ray is passed through the insensitive region, reflected by the second reflecting film, and incident on the photo-detector, photoelectric conversion derived from optical resonance hardly occurs to the photo-detector. It is thereby advantageously possible to enhance the spatial resolution of the imaging device.

[Brief Description of the Drawings]

[Fig. 1]

Fig. 1 is a cross-sectional view illustrating an infrared solid-state imaging device in the first embodiment of this invention.

[Fig. 2]

Fig. 2 is a cross-sectional view illustrating the infrared solid-state imaging device in the second embodiment of this invention.

[Fig. 3]

Fig. 3 is a cross-sectional view illustrating a conventional rear surface incident infrared solid-state imaging device.

[Fig. 4]

Fig. 4 illustrates the relationship between a detector-to-reflecting film distance (d) and a photoelectric conversion efficiency of a reflected

infrared ray.

[Fig. 5]

Fig. 5 is a block diagram illustrating one example of an installation method if a rear surface incident infrared solid-state imaging device is attached to the cooler.

[Fig. 6]

Fig. 6 is a cross-sectional view illustrating another example of the conventional rear surface incident infrared solid-state imaging device.

[Description of Reference Symbols]

1 P-type silicon substrate

2 platinum silicide

3 guard ring

4 CCD channel

5 P-type impurity region

6 oxide film

7 polysilicon gate

8 interlayer insulating film

9 Al reflecting film (first reflecting film)

10 protection film

17 infrared absorption layer

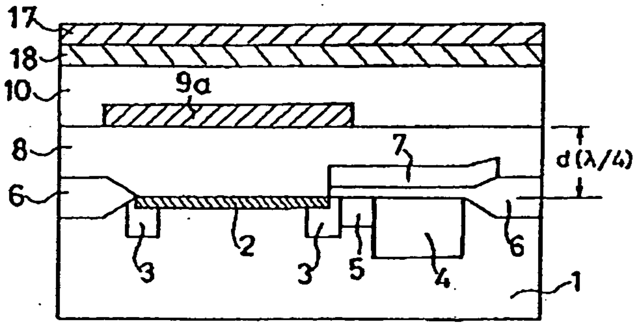
18 non-reflection coat layer

19 Al reflecting film (second reflecting film)

20 protection film

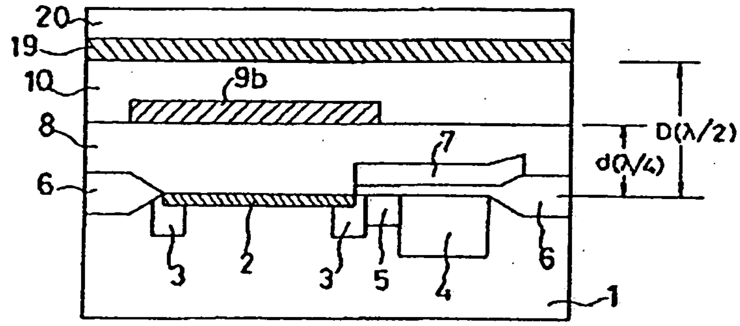
Fig. 1

1 P-type silicon substrate 3 guard ring
2 platinum silicide 4 CCD channel



5 P-type impurity region 9a Al reflecting film
6 oxide film 10 protection film
7 polysilicon gate 17 infrared absorption layer
8 interlayer insulating film 18 non-reflection coat layer

Fig. 2



19 second Al reflecting film 20 protection film

Fig. 3

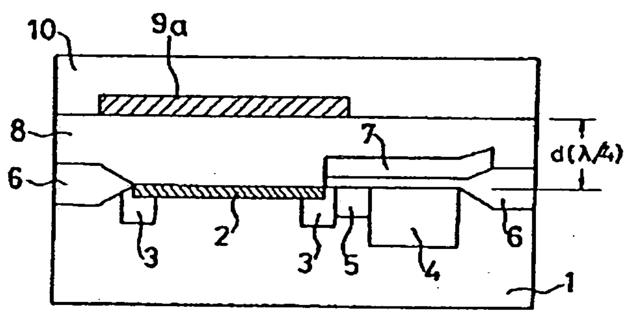


Fig. 4

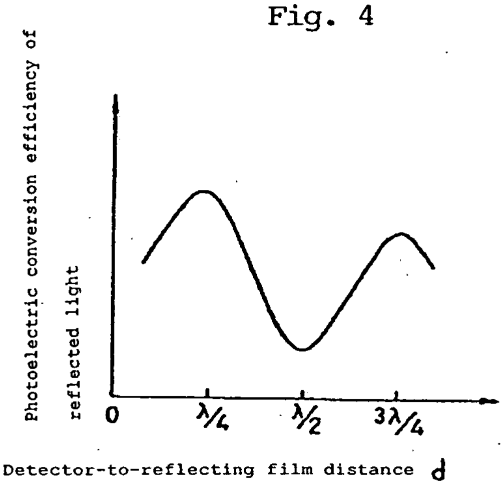


Fig. 5

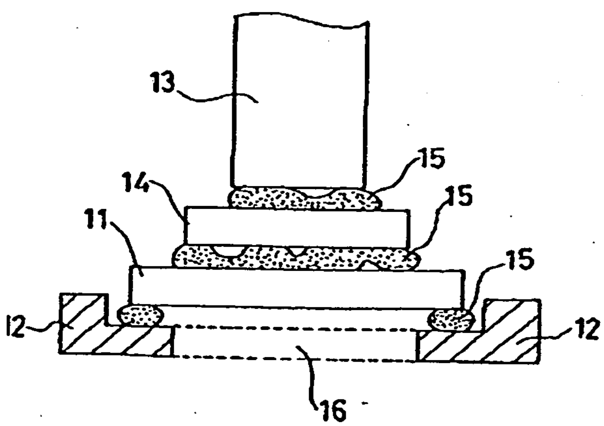


Fig. 6